Continental Shelf Embayments of the Eastern Margin of the Philippines; Lamon Bay Stratification & Circulation

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LONG-TERM GOALS

To investigate the circulation, stratification and the Shelf-Slope interaction, and the resultant ocean productivity, within a major embayment, Lamon Bay, of the eastern margin of the Philippines.

OBJECTIVES

The research objectives of the Lamon Bay program is to quantity the spatial and temporal characteristics of the ocean processes governing the stratification & circulation within Lamon Bay and their relationship to regional marine productivity and ecosystems and to investigate possible linkage of Lamon Bay dynamics to the larger scale, such as the development of the Kuroshio.

APPROACH

The observational program consists of integrated physical and biological oceanography measurements, obtained from ship-based underway oceanographic and meteorological sensors, including the hull mounted ADCP; and by water column stations (CTD-O2 with a 24-bottle 10-liter water sample rosette, which extended to 1500 m or to near the sea floor if shallower than 1500 m). The sea floor sediment will be sampled with gravity cores.

The research cruise is carried out in the May/June 2011 (Lamon Bay 1) with a follow up cruise in the same time frame 2012 (Lamon Bay 2). The ship based surveys are tied together by mooring based time series observations of ocean currents and T/S stratification and by a land based high frequency radio array, as well as satellite coverage of SST, ocean color and altimetry, and larger scale ocean observations by global observational programs and by OKMC (Origin of the Kuroshio and Mindanao Current)

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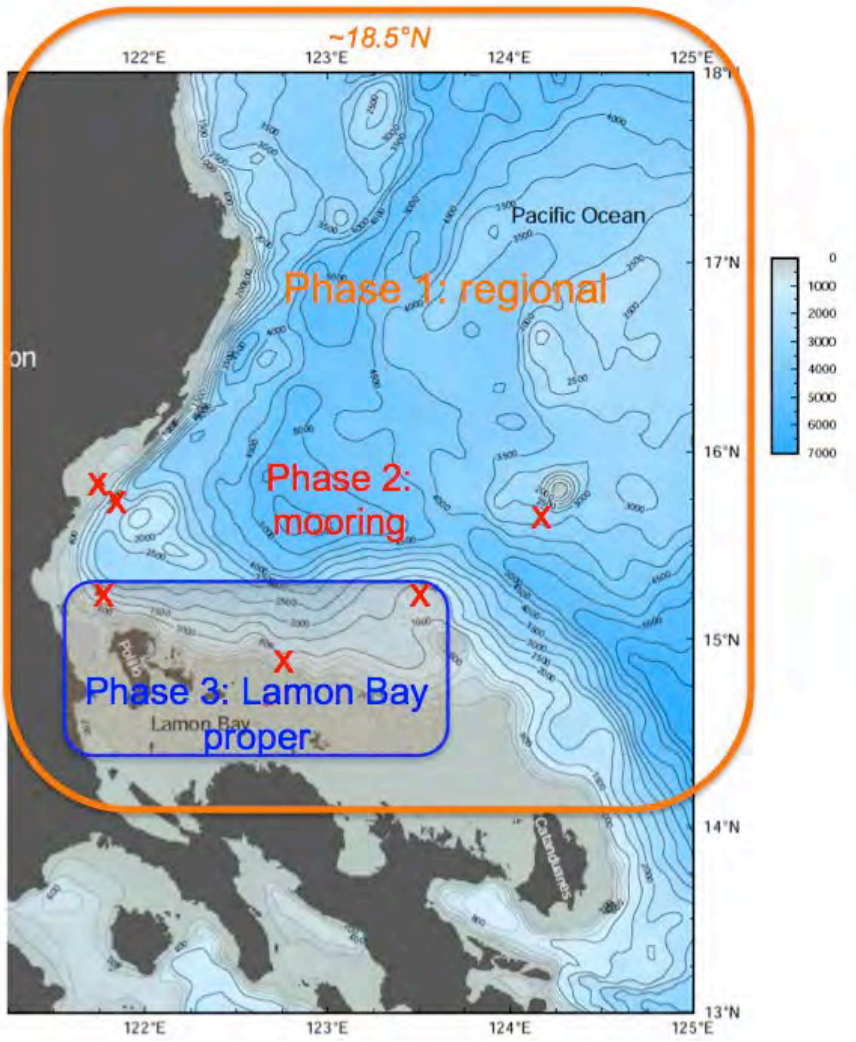

Figure 1 Lamon Bay 2011 research cruise approach: The cruise plan may be viewed as involving 3 phases: Phase 1 Regional Survey to resolve stratification and circulation conditions seaward of Lamon Bay Proper. The return to Port Irene at the end of the cruise provides additional opportunity to contribute to the Regional Survey; Phase 2 Mooring Deployment; Phase 3 physical and biological conditions within Lamon Bay southern tier (Lamon Bay Proper). The red X symbol marks the approximate sites of the year-long moorings for current and temperature/salinity time series measurements

This program represents a collaboration with Cesar Villanoy and colleagues of Marine Science Institution in the Philippines; with Pierre Flament, University of Hawaii; A. Gordon of Lamont-Doherty Earth Observatory of Columbia University.

WORK COMPLETED

The first of the two research cruises were accomplished on the R/V Roger Revelle from Kao-hsiung, Taiwan 18 May 2011 to Kao-hsiung, Taiwan, 6 June 2011, with Personnel exchange at Port Irene, Philippines on 19 May and 4 June.

The ship track and CTD station distribution is shown as Figure 2. The track to the south of 14°N marks a diversion due to the passage of Typhoon Songda across Lamon Bay. The interval of time lost to addressing explicit Lamon Bay objectives due to Typhoon Songda was ~4 days. On the positive side, the diversion provided opportunity to gather ship based underway data across the North Equatorial Current Bifurcation.

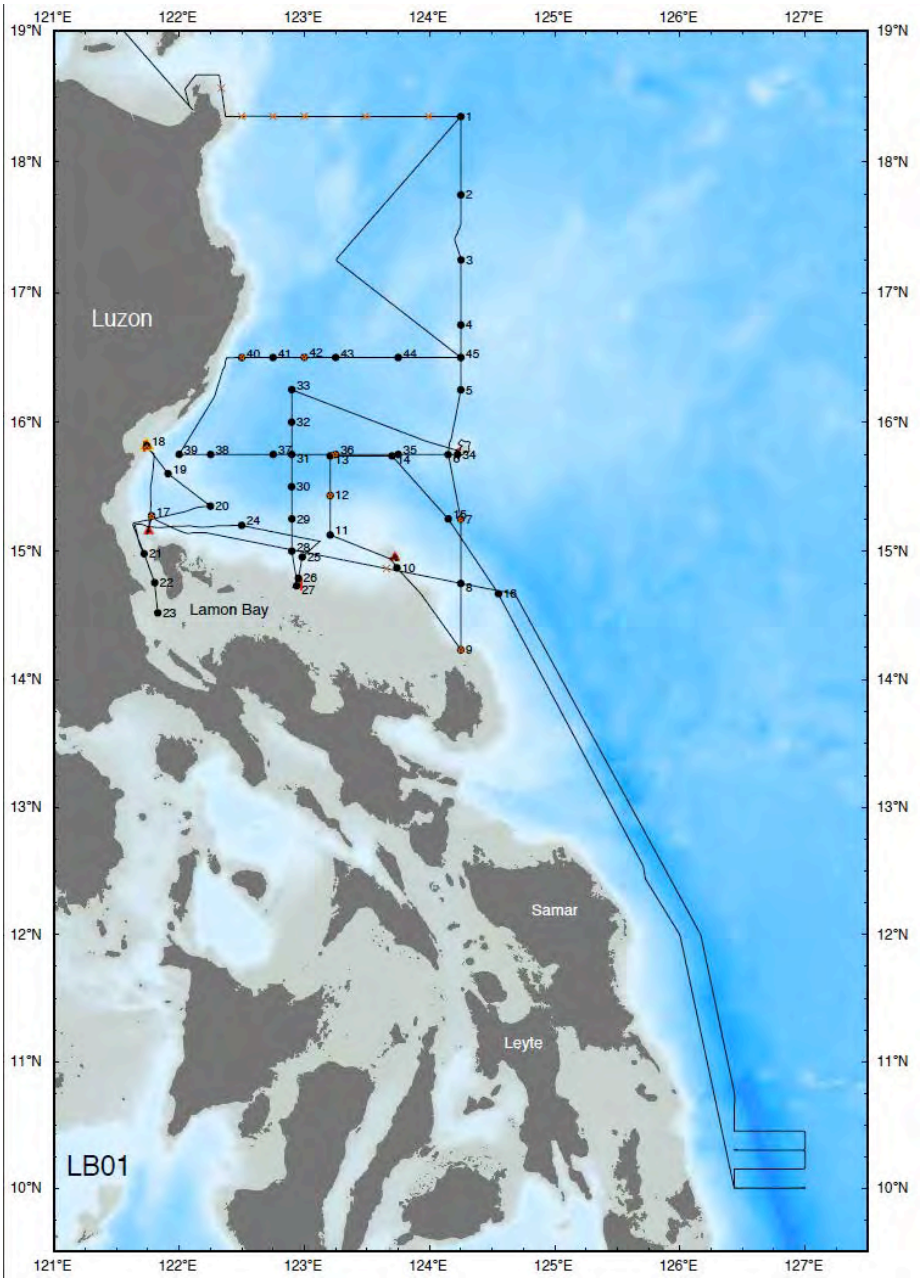

Figure 2. Station/track map of Lamon Bay 1. Red dots show drifter deployments [13 Surface Velocity Program (SVP) drifters were deployed in cooperation with L. Centurioni (SIO).]; red triangles are mooring deployment sites [6 in total, also see figure 3 and Table 1]. There were 45 CTD stations most with water samples for chemistry. CTD/water sampling stations extended to 1500 m, or to the sea floor, if <1500 m.

The year-long moorings (Table 1) for current and temperature/salinity time series measurements are shown as red X symbol on Figure 3.

Table 1 Moorings deployed during Lamon Bay #1 [to be recovered in 2012]:

what	long°E	latitude°N	Day GMT	depth
TRBM1	123.7233	14.9517	22may2011	145
TRBM2	121.7572	15.1581	27may2011	192
TRBM3:	121.7415	15.8186	28may2011	180
T/S Bottom:	121.7201	15.8158	28may2011	86
Mooring [line] 1	122.9715	14.7405	30may2011	226
Mooring [line] 2	124.2274	15.7540	31may2011	757

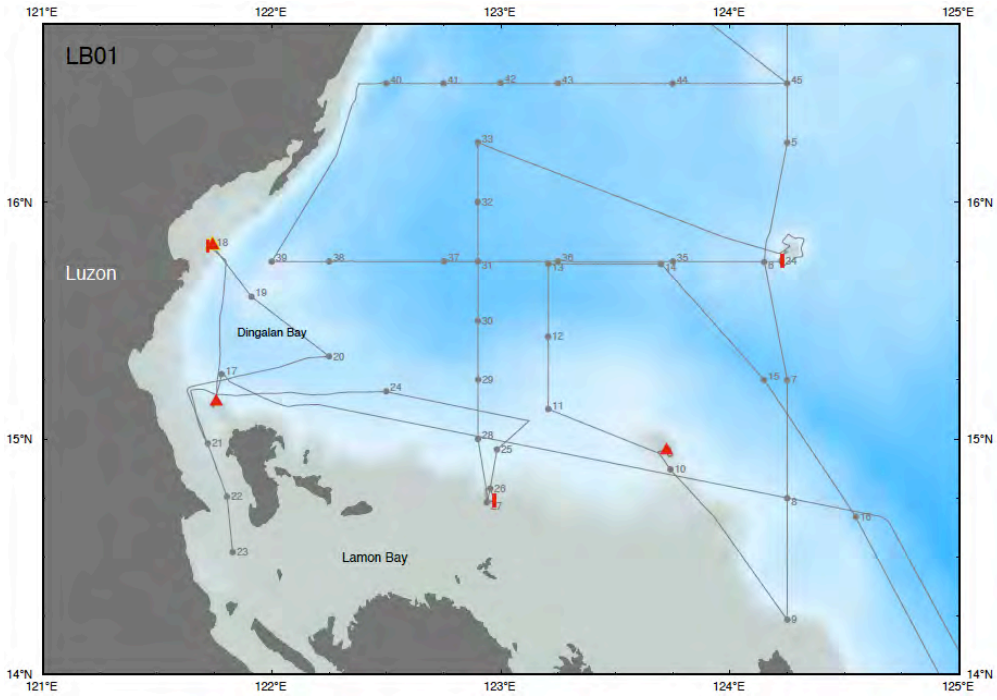

Figure 3: CTD station distribution within Lamon Bay proper (Phase 2 and 3, see figure 1). red triangles = TRBM (trawl-resistant bottom mount); red bars: T/S moorings with cable]

RESULTS

The circulation within Lamon Bay (Figures 4, 5, 6) is vigorous, with surface layer currents often between 1 and 2 kts. The Kuroshio at 18.35°N (northeastern tip of Luzon) was nearly 3 kts at the sea surface, and extended to ~350 m. Within Lamon Bay are 2 energetic gyres or dipoles that bracket a northwestward stream into the Kuroshio. These features extend to only 150-200 m. The cyclonic dipole is within the southern tier of Lamon Bay; the much more energetic anticyclonic dipole is to the north of the Kuroshio feeder stream. This sets up a bifurcation along the western boundary of Lamon Bay, near 16°-17°N, which is likely more relevant to the Kuroshio than the bifurcation near 13°N. The first occurrence of a clear Kuroshio is at the western boundary at 16.5°N. The vorticity transfer linking the nascent Kuroshio to the dipoles needs to be considered in understanding the origin of the Kuroshio.

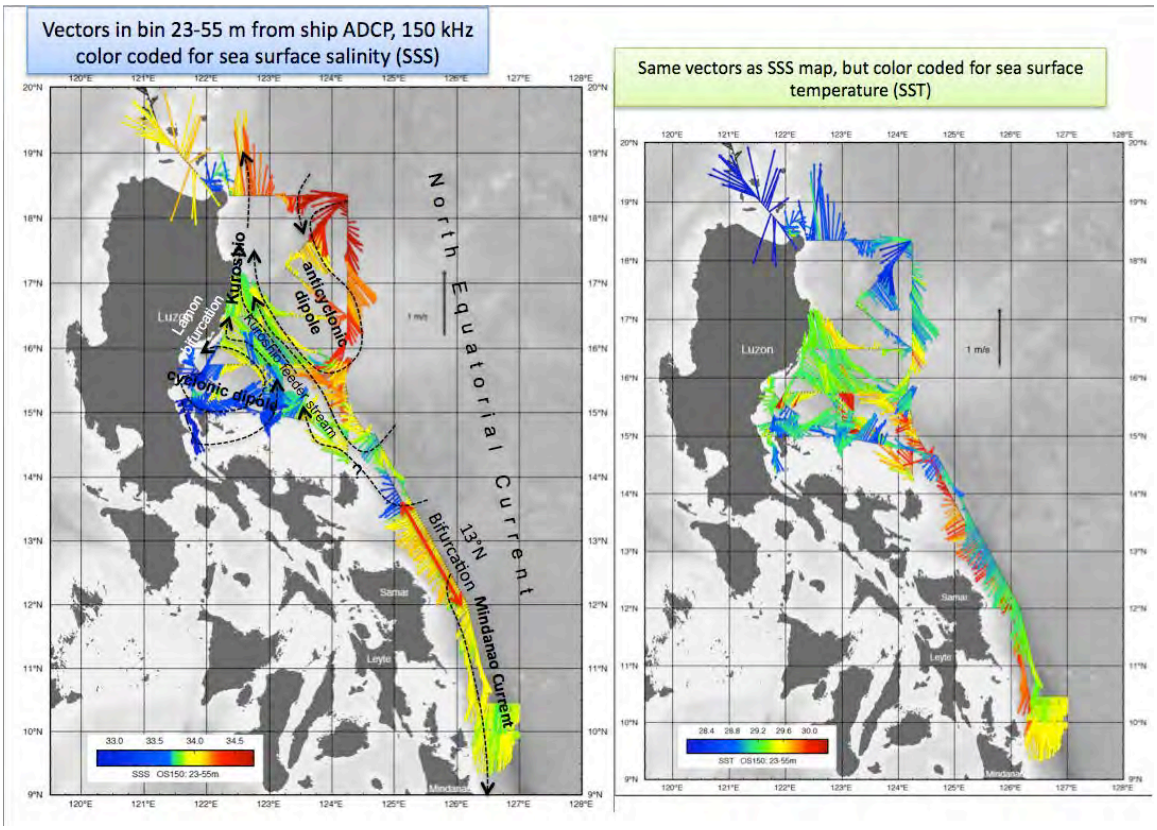

Figure 4 Regional Circulation 23-55 m interval, color coded vectors by sea surface salinity (SSS) and sea surface temperature (SST). See figures 7a and 8a for a blow up of the Bifurcation and Lamon Bay regions, respectively. The first clear sign of a northward flowing western boundary Kuroshio is at 16 to 17°N. Continuity of significant northward flow from the 13°N bifurcation into Lamon Bay is not clear, main activity appears to be associated with the cyclonic and anticyclonic dipoles with Lamon Bay

The Lamon Bay dipole has a branch entering into Polillo Strait, and then exported from the shelf north of Calagua Island, introducing low salinity surface water into the Lamon Bay cyclonic dipole.

Lamon Bay is a confluence of waters from different ocean regimes, which eventually contribute to the Kuroshio. The Kuroshio off the northeastern point of Luzon is mainly drawn from North Pacific subtropical water (subtropical component of the North Equatorial Current) and western North Pacific Kuroshio recirculation (Figure 4). Input from the equatorial component of the North Equatorial Current, derived from the bifurcation near 13°N, is small. From continuity it is limited in the long-term to compensate for the loss of upper kilometer water form the North Pacific: Bering Strait export to the Arctic and export of North Pacific Intermediate water to the Mindanao Current; estimate: ~ 4 Sv.

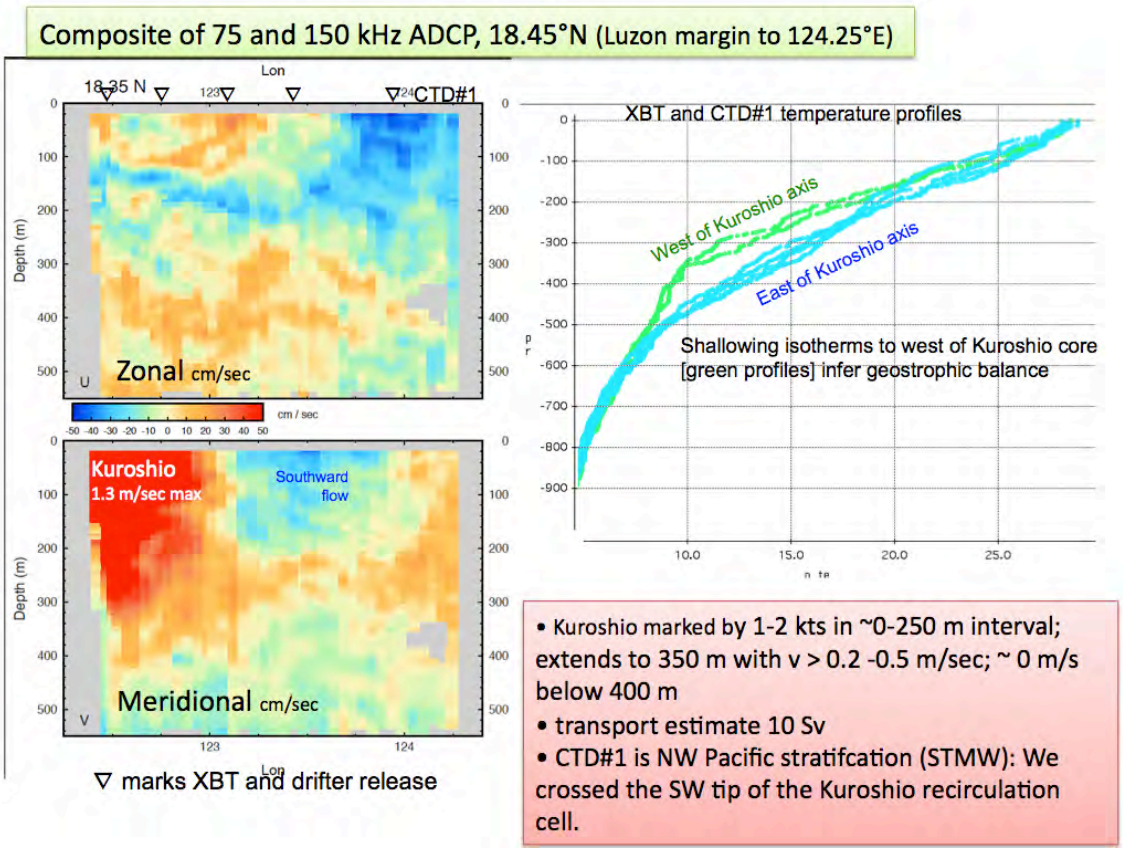

Figure 5a: Kuroshio Crossing at 18.35°N

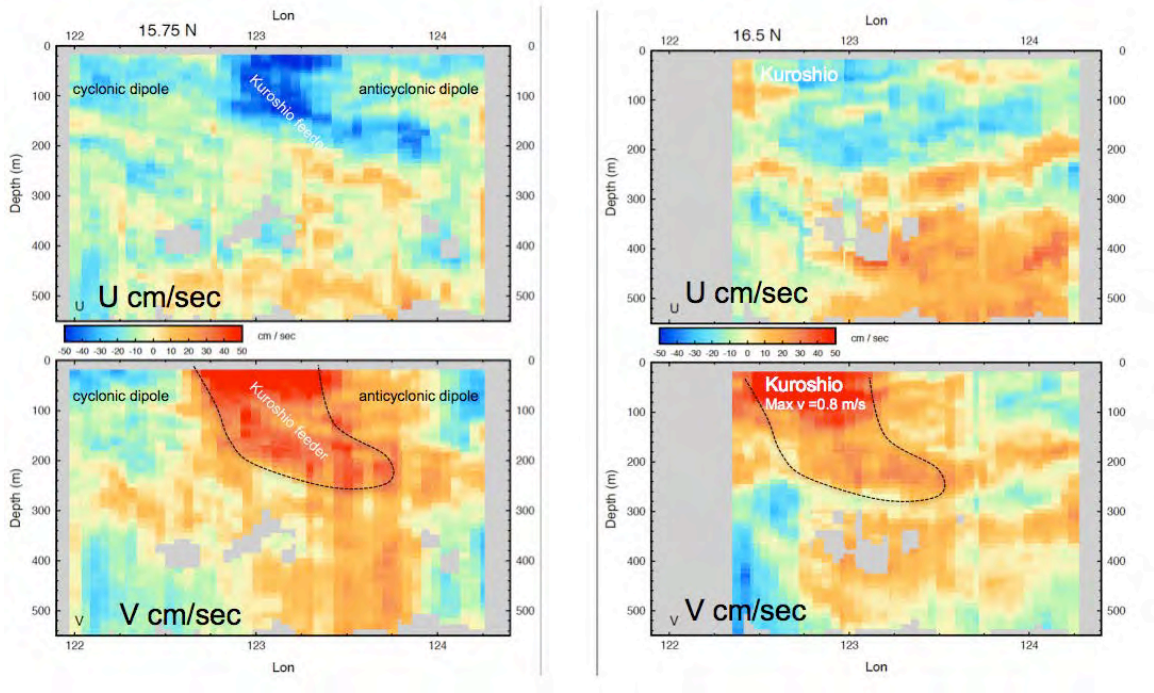

Figure 5b: Composite of 75 and 150 kHz ADCP, at 15.75 and 16.50°N. The northward flowing western boundary current at 16.5°N may be considered the southern-most, clearest expression of the Kuroshio. The Kuroshio 'takes shape' within Lamon Bay, between the dipoles. Estimated transport of Kuroshio at 16.5°N is 11 Sv (using u and v; the same as observed earlier in the cruise at 18.35°N). The Kuroshio extends to around 300 m; its axis shifts eastward with increasing depth. This is also observed within the Kuroshio feeder stream at 15.75°N

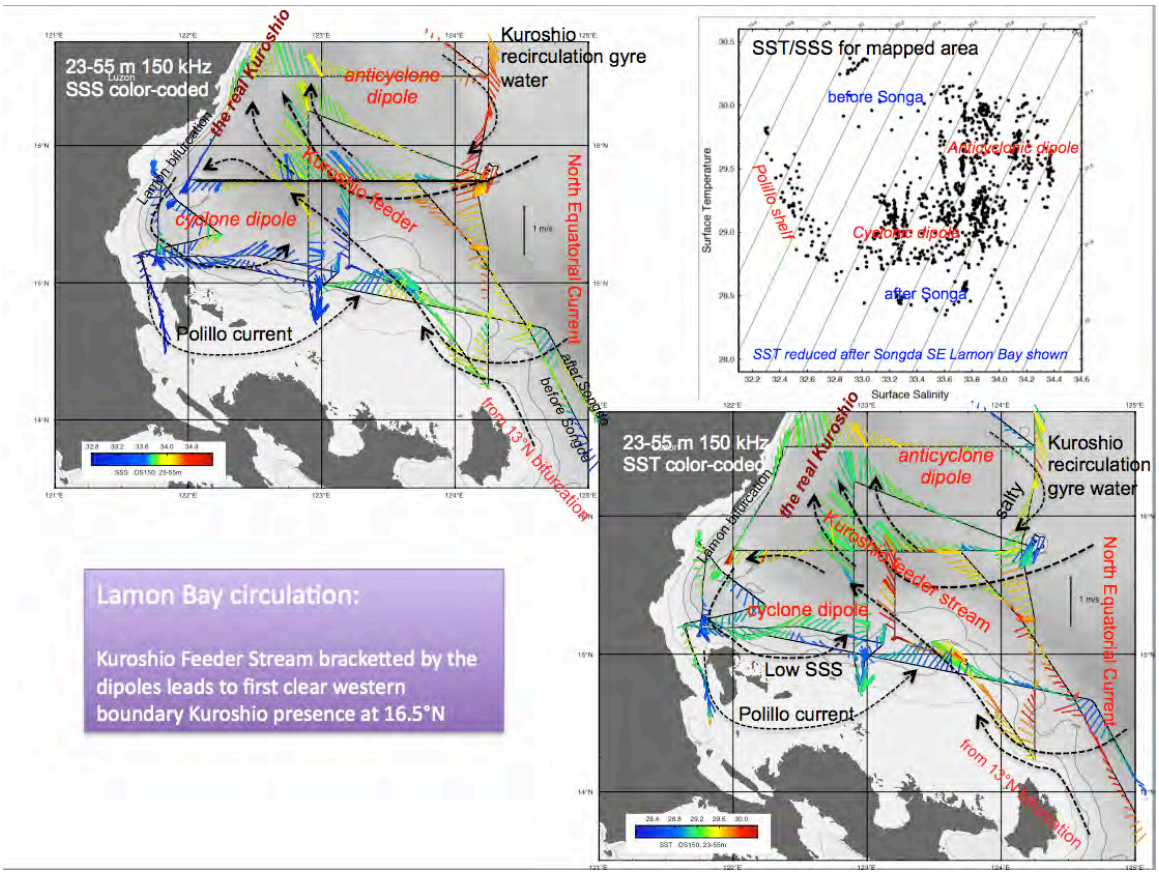

Figure 6. Lamon Bay circulation, showing the anticyclonic and cyclonic dipoles, surface water T/S, and ADCP section along 15.75°N. The dipole and Kuroshio feeder stream between the dipoles extend to <200 m, the sea surface to the mid-pycnocline levels.

The Lamon Bay project mooring will provide 1-year record of the dipoles and Kuroshio feeder stream behavior. The Lamon Bay 2012 cruise will provide another snapshot to test the concepts drawn from the Lamon Bay 2011 cruise.

IMPACT/APPLICATIONS

The spatial and temporal shelf/slope interactions processes within and at the boundaries of Lamon Bay may be instrumental in the origin and dynamics of the Kuroshio Current including the links of the Kuroshio to the North Pacific subtropical gyre and Pacific North Equatorial Current Bifurcation. The Lamon Bay dipole circulation pattern is likely closely linked to the active marine ecosystem characteristic of Lamon Bay.

TRANSITIONS

None

RELATED PROJECTS

OKMC (Origin of the Kuroshio and Mindanao Current)

REFERENCES

PUBLICATIONS

PATENTS

None